Community Education for Cardiovascular Disease Prevention: Risk Factor Changes in the Minnesota Heart Health Program

ABSTRACT

Objectives. The Minnesota Heart Health Program is a 13-year research and demonstration project to reduce morbidity and mortality from coronary heart disease in whole communities.

Methods. Three pairs of communities were matched on size and type; each pair had one education site and one comparison site. After baseline surveys, a 5- to 6-year program of mass media, community organization, and direct education for risk reduction was begun in the education communities, whereas surveys continued in all sites.

Results. Many intervention components proved effective in targeted groups. However, against a background of strong secular trends of increasing health promotion and declining risk factors, the overall program effects were modest in size and duration and generally within chance levels.

Conclusions. These findings suggest that even such an intense program may not be able to generate enough additional exposure to risk reduction messages and activities in a large enough fraction of the population to accelerate the remarkably favorable secular trends in health promotion activities and in most coronary heart disease risk factors present in the study communities. (*Am J Public Health.* 1994;84:1383–1393)

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Introduction

Cardiovascular diseases, principally coronary heart disease and stroke, remain the leading causes of death and disability in industrialized countries. They are preventable and reversible through the modification of risk factors, including elevated blood lipids, elevated blood pressure, cigarette smoking, and sedentary life-style.[1–4] Entire populations are at increased risk because of mass elevated risk factors in which individual susceptibility is enhanced by culture, economic factors, and the environment. Population risk should be amenable to change through communitywide strategies,[5] and several community intervention research and demonstration projects are under way or completed in the United States and Europe.[6–12]

The largest of these studies in the United States is the Minnesota Heart Health Program. Initiated in 1980, the Minnesota Heart Health Program involves approximately 400 000 persons in six communities in the Upper Midwest. It was hypothesized that a 5- to 6-year intervention program would (1) improve health behaviors; (2) lower population levels of blood cholesterol by 7 mg/dL, blood pressure by 2 mm Hg, and cigarette smoking by 3% and increase population physical activity levels by 50 kcal/day; and (3) that these changes would subsequently reduce cardiovascular disease morbidity and mortality by 15%. Risk factor levels and associated behaviors were measured before the start of the intervention program and annually for 6 or 7 years of follow-up in all six communities; morbidity and mortality data are being collected annually from the six communities and surrounding states. The purpose of this paper is to present the main risk factor results of the study.

Methods

Study Design

The design of the Minnesota Heart Health Program is described elsewhere[6] and summarized here (Figure 1). Three pairs of communities were selected; each pair had one education site and one

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This paper was accepted April 6, 1994.

Editor's Note. See related editorial by Winkleby (p 1369) in this issue.

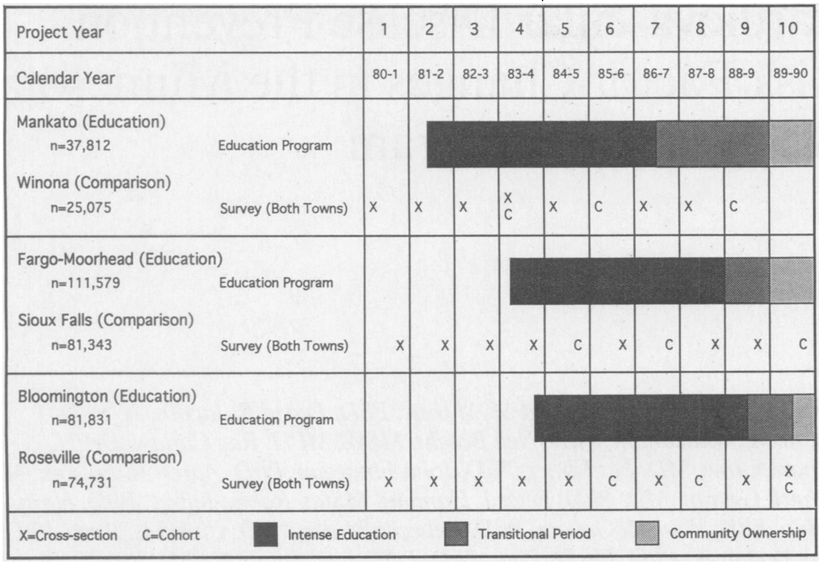
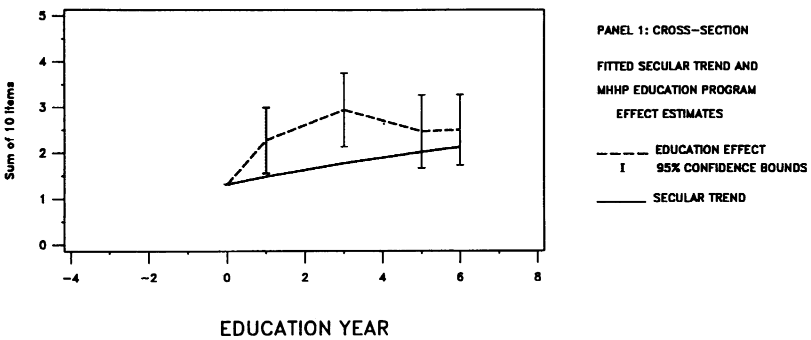


FIGURE 1—Minnesota Heart Health Program study design. Reprinted from Murray et al.[50] with permission. Copyright © 1994 *American Journal of Epidemiology.*



Note. Adjusted for age, gender, and education. MHHP = Minnesota Heart Health Program.

FIGURE 2—Exposure score: results of the MHHP education intervention program.

comparison site matched on size (25 000–110 000), community type (small, medium, urban), and distance from the Minneapolis–St. Paul metropolitan area (<250 miles). Assignment of communities to intervention within pairs was nonrandom and completed before collection of the data. After a 16-month baseline period, a 5- to 6-year intervention program was introduced in November 1981 in Mankato, Minnesota, a rural community in southern Minnesota. The program was introduced 22 and 28 months later, respectively, in Fargo–Moorhead, an urban area consisting of two neighboring communities along the North Dakota–Minnesota border, and in Bloomington, Minnesota, a large Minneapolis–St. Paul suburb. The staggered entry allowed for gradual development of the intervention program and strengthened the design through replication; it also provided two, three, and four baseline surveys in the first, second, and third pairs, respectively, to improve the precision of the preintervention time trends estimated from the data.

Survey Methods

Cross-sectional surveys. Cross-sectional surveys of 300–500 randomly selected adults were conducted periodically in each community, with a two-stage cluster sampling design.[13] Initially, census blocks were randomly selected from each city, with the probability of selection proportional to the expected number of households. Geographically adjacent groups of five households were randomly selected from within those blocks. Within households, a single age-eligible adult was selected at random. This procedure was repeated for the second survey sample; subsequent samples were drawn from the census blocks selected in the first 2 years. Matched communities were surveyed in adjacent 2-month periods.

After selection, initial household contact was by letter, followed by direct interview to (1) enumerate the household; (2) randomly select one age-eligible subject; (3) collect data on sociodemographic characteristics, medical history, health attitudes and beliefs, and smoking history; and (4) extend an invitation to visit a survey center for risk factor measurements. Those who spoke no English or who were judged mentally incompetent to participate were ineligible (<5%), and some participants were examined at home (<5%).

Cohort surveys. Periodic remeasurements were made in a cohort comprised of participants selected at random from all of the preintervention cross-sectional surveys. To minimize the effect of repeated testing, remeasurements were structured so that approximately half the cohort was selected at random for recontact after 2 years of intervention, whereas the other half was recontacted after 4 years. The entire cohort was recontacted after 6–7 years of intervention. As expected, there were no differences in baseline risk factors between the two halves of the cohort.

Measurements

Detailed methods for risk factor measurements are reported elsewhere[14] and are only summarized here.

Blood pressure was measured in a seated position with a random-zero sphygmomanometer (Hawksley–Gelman, London, England) and an appropriate-sized cuff after a 5-minute rest. Two measurements of systolic and fifth-phase diastolic pressure were made 1 minute apart and averaged for the analysis.

Blood was obtained according to the methods described in the Lipid Research Clinic's protocol.[15] Serum total cholesterol was measured in the Minnesota Lipid Research Clinic's laboratory by an Autoanalyzer II (Technicon Instrument

TABLE 1—Pooled Education and Comparison City-Year Means from the Cross-Sectional Surveys, Adjusted within Strata and Standardized across Strata, before Modeling of Secular Trends and Minnesota Heart Health Program Intervention Effects

		Education Year[a]							
		−3[b]	−2[b]	−1	0	1	3	5	6
Exposure score (range, 1–10)	Education				1.3	2.3	2.9	2.4	2.5
	Comparison				1.2	1.6	1.8	1.9	2.1
Blood cholesterol, mg/dL	Education	213.5	207.2	206.5	207.3	199.8	199.0	204.1	203.8
	Comparison	212.3	208.2	209.3	208.3	208.8	199.4	199.9	203.8
Smoking, males (% smokers)	Education	38.7	45.2	34.5	37.9	34.0	33.7	30.4	29.4
	Comparison	34.5	43.8	36.3	39.5	32.3	31.6	27.2	31.1
Smoking, females (% smokers)	Education	25.3	31.6	33.3	28.0	30.5	23.8	22.8	22.8
	Comparison	22.1	31.0	29.3	27.8	26.7	23.4	28.3	26.0
Systolic blood pressure, mm Hg	Education	120.8	120.7	121.5	121.7	121.6	118.2	119.4	118.6
	Comparison	124.5	122.6	124.3	125.7	124.4	121.7	120.5	121.6
Diastolic blood pressure, mm Hg	Education	74.6	73.8	75.2	76.2	75.4	71.6	73.4	73.3
	Comparison	76.5	74.0	76.6	76.8	75.1	74.5	74.1	74.1
Body mass index, kg/m^2	Education	25.3	25.6	25.8	25.6	25.7	26.0	26.3	26.0
	Comparison	25.5	25.7	25.8	25.8	26.3	26.2	26.4	26.5
Physical activity (% active)	Education	50.9	49.5	45.5	48.4	54.2	54.3	55.2	57.1
	Comparison	52.1	49.0	50.3	47.3	48.4	51.3	53.9	52.8
Coronary heart disease risk (deaths/1000 persons)	Education	28.7	26.9	26.5	25.5	26.3	22.6	23.8	24.4
	Comparison	32.2	35.3	33.7	33.6	34.3	29.7	28.1	31.2

[a]Negative values refer to observations made before the intervention program; a value of 0 refers to observations made immediately before the intervention program; positive values refer to observations made after the intervention program began.
[b]Data were not collected from Mankato, Winona in E-3 or E-2, nor in Fargo/Moorhead, Sioux Falls in E-3; pooled means for E-3 and E-2 were calculated after imputing values for the missing components based on the differences in the city levels as estimated in the regressions.

Corporation, Tarrytown, NY).[16] Quality control of Lipid Research Clinic laboratories was maintained by external standardization with the Centers for the Disease Control (CDC),[16] and the values were adjusted for daily variability against standard CDC pools.[17]

Participants were classified as current smokers if they had ever smoked at least 100 cigarettes in their lifetime and smoked at present. Serum thiocyanate was also measured.[18]

Height and weight were measured in stocking feet and light clothing. Height was measured to the nearest centimeter with a fixed metal rule. Weight was measured to the nearest half pound with a balance beam scale. Body mass index was computed as kilograms per square meter.

Leisure time physical activity was assessed as the percentage of participants who answered "yes" to the question, "Are you regularly active in your leisure time?"

A risk reduction exposure score, which was constructed from 10 questions about recent participation in activities such as smoking cessation classes, cholesterol screening, and so forth, was added when intervention began. The score ranged from 0 to 10, and all items were designed to be equally applicable in all communities.

Other variables were employed as stratification factors (age, gender, educational attainment) or as covariates (specific to each outcome and identified in Figures 2–10).

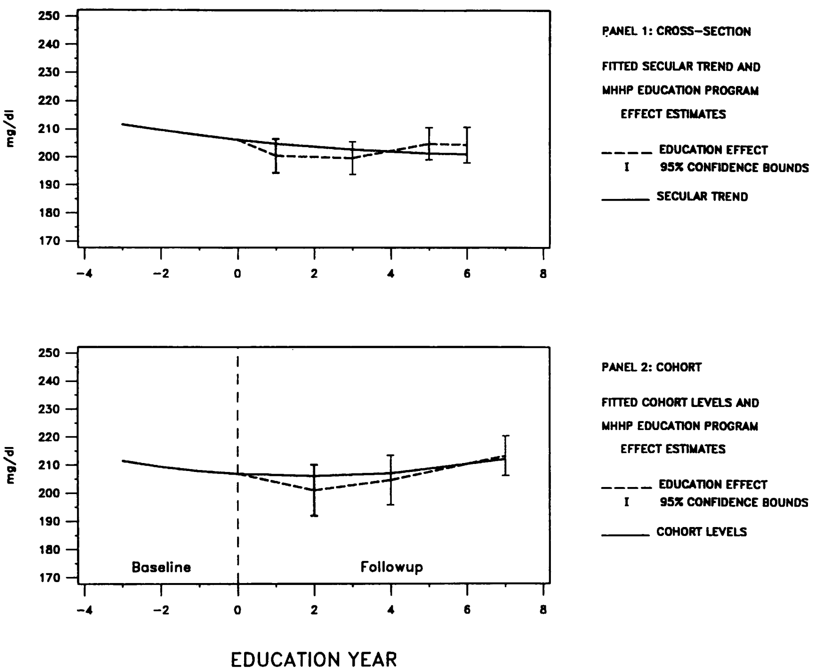
Scores for the risk per 1000 persons of death from coronary heart disease in 10 years were computed according to the method of Truett et al.[19] with the coefficients provided by Leaverton et al.[20]; separate functions were used for men and women.* The variables included were age in years, systolic blood pressure, total cholesterol, and cigarette smoking.

*Risk = 1000 * $(1/1 + e^{-c})$.
For men: $c = -9.42705 + 0.0644(\text{age}) + 0.0131(\text{SBP}) + 0.0046(\text{CHOL}) + 0.7809(\text{SMK})$.
For women: $c = -15.1298 + 0.1059(\text{age}) + 0.0223(\text{SBP}) + 0.0097(\text{CHOL}) + 0.8823(\text{SMK})$.

Intervention Methods

The Minnesota Heart Health Program intervention advocated hypertension prevention and control, healthy eating patterns for lower blood cholesterol and blood pressure, nonsmoking, and regular physical activity. It operated at the individual, group, and community levels and embraced a wide range of strategies and theories, including social learning theory,[21] persuasive communications theory,[22,23] and models for involvement of community leaders and institutions.[24] The program alerted people to health issues, informed them of effective behavioral alternatives for health promotion, provided incentives for new behaviors, and provided reinforcements to maintain new behaviors.

Community analysis and organization methods were used to engage community leaders and organizations as active participants in the intervention programs; this effort resulted in their active involvement, gradual environmental change to support risk reduction, and community planning for program continuation.[25–27] Mass media were used to increase individual exposure to the Minnesota Heart Health Program risk factor messages, establish awareness of the program, and increase the salience of the program



Note. Adjusted for age, gender, education, and seasonal trend. MHHP = Minnesota Heart Health Program.

FIGURE 3—Total cholesterol: results of the MHHP education intervention program.

messages.[28–32] Health professionals in the education communities were involved through their local organizations and preventive practice advisory committees, and they served as role models and opinion leaders.[33,34] Systematic risk factor screening and education were conducted during the first 3 years of the intervention program; over 60% of all adult residents received on-site measurement, education, and counseling.[35] The adult education component made available personal, intensive, and multiple contact programs to reduce cardiovascular risk; this strategy focused on self-management and included changes in existing behaviors, in the meaning of those behaviors, and in the environmental cues that supported those behaviors.[36–44] Direct education programs for school-age children discouraged health-compromising behaviors and promoted health-enhancing behaviors in youth and their parents.[45–47]

The program included a high-intensity campaign via the mass media, recruited virtually all primary care physicians and many other health professionals to training programs, recruited more than 60% of all adults age 25–74 to the screening and education programs, recruited more than 30% of all adults to

TABLE 2—Pooled Education and Comparison City-Year Means from the Cohort Surveys, Adjusted within Strata and Standardized across Strata, before Modeling of Trends or Minnesota Heart Health Program Intervention Effects

		Education Year[a]						
		−3[b]	−2[b]	−1	0	2	4	7
Blood cholesterol, mg/dL	Education	216.3	208.7	206.3	206.8	201.3	202.5	213.0
	Comparison	212.3	205.7	209.4	209.7	207.6	207.0	213.0
Smoking, males (% smokers)	Education	30.8	39.0	27.0	32.2	27.5	26.0	21.4
	Comparison	26.6	36.2	27.7	34.4	24.7	26.7	19.6
Smoking, females (% smokers)	Education	23.8	32.9	30.8	26.7	24.7	22.9	19.6
	Comparison	23.2	28.1	30.5	27.9	25.0	24.1	19.6
Systolic blood pressure, mm Hg	Education	121.0	120.4	121.3	122.3	121.2	120.4	121.3
	Comparison	123.1	122.2	123.9	126.0	124.0	123.4	123.6
Diastolic blood pressure, mm Hg	Education	74.7	73.1	74.6	76.2	74.8	75.0	75.8
	Comparison	75.5	73.9	76.0	76.8	76.3	74.9	75.8
Body mass index, kg/m^2	Education	25.7	25.7	25.9	25.8	26.0	26.5	26.8
	Comparison	25.4	25.8	25.6	25.9	26.2	26.5	26.9
Physical activity (% active)	Education	51.8	49.3	45.0	49.4	56.6	57.4	63.6
	Comparison	55.0	48.3	51.5	49.1	58.4	58.2	58.6
Coronary heart disease risk (deaths/1000 persons)	Education	27.0	25.4	24.4	24.7	30.7	32.3	41.0
	Comparison	31.2	32.5	31.6	31.0	38.2	43.4	50.4

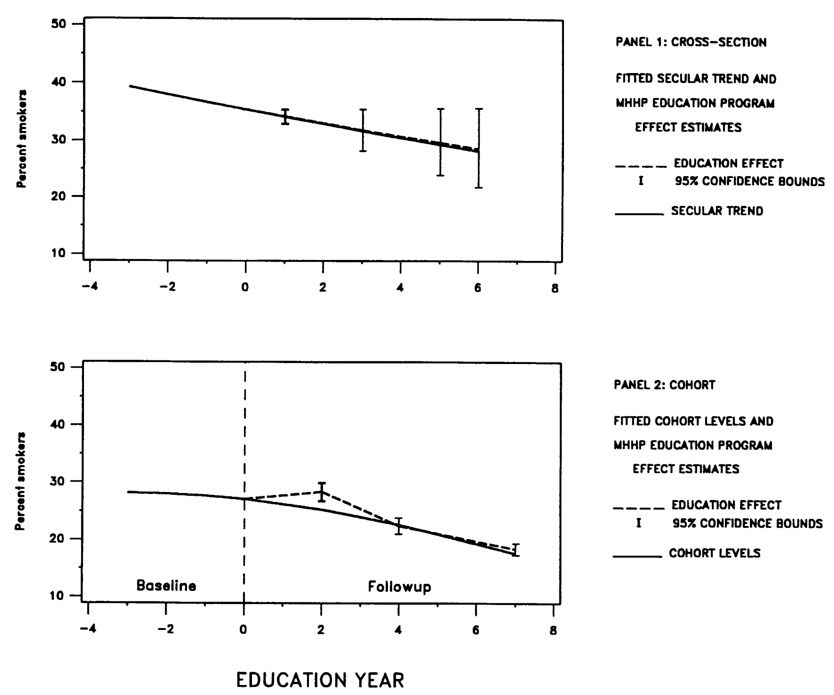
[a]Negative values refer to observations made before the intervention program; a value of 0 refers to observations made immediately before the intervention program; positive values refer to observations made after the intervention program began.
[b]Data were not collected from Mankato, Winona in E-3 or E-2, nor in Fargo/Moorhead, Sioux Falls in E-3; pooled means for E-3 and E-2 were calculated after imputing values for the missing components based on the differences in city levels as estimated in the regressions.

face-to-face intervention programs, involved organizations in environmental change programs, and involved most of the resident youth in school-based health promotion activities.

Analysis Methods

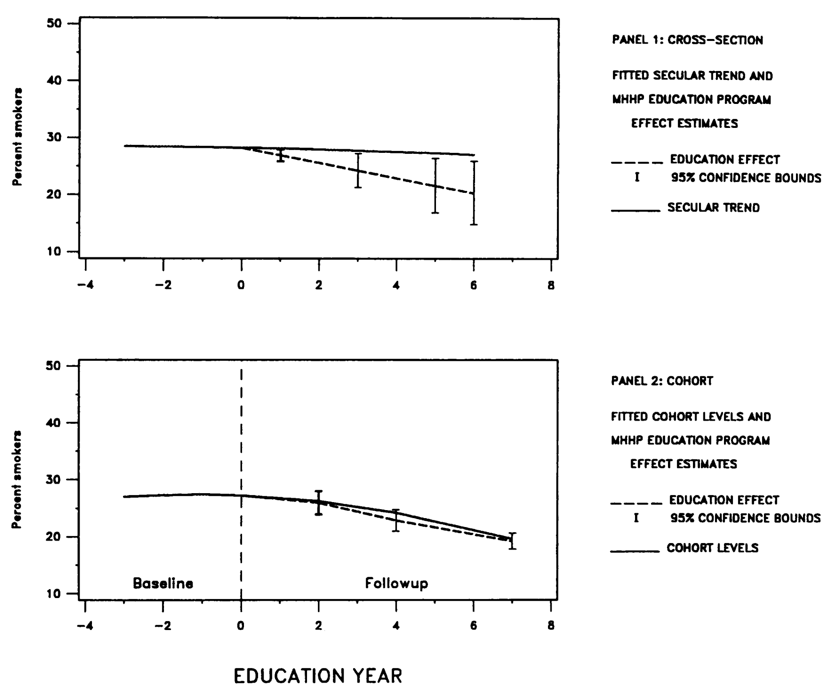
By design, the community was the unit of assignment, whereas the individual was the unit of observation. Persons within clusters such as communities tend to be more like one another than they are like persons in other communities,[13] and this within-cluster correlation adds an additional component to the variability of the treatment group means over that attributable either to the individual participants or to the treatments.[48] Unless this extra variation is accounted for in analysis, the *P* values for the treatment effects will be artificially deflated.[49] We accounted for the extra variation through a two-stage analysis that approximated a stratified hierarchical analysis of covariance; the nested communities were treated as random effects; condition, time, and stratification factors were treated as fixed effects; and all tests of statistical significance were made at the community level.[50,51]

In the first stage, least-squares adjusted means were generated for each city in each survey year after stratifying simultaneously by gender, educational attainment, and age; adjustments were made for confounding variables specific to each dependent variable by standardizing all subjects to the population average within strata for each covariate. The second stage employed these adjusted strata-specific city-year means as the unit of analysis in a series of regressions to evaluate the main and strata-specific effects of the intervention program as a time-by-treatment interaction. Recognizing that planned contrasts can provide tests that are more interpretable and potentially more powerful, we tested two specific patterns of program effect. For both patterns, a quadratic secular trend was modeled by using the baseline intervention city-year means together with all of the comparison city-year means. The intervention program effect was then modeled first as a series of year-specific departures from that secular trend and second as a linear departure from that trend. The analysis of the cohort data followed the same plan; modifications were made to accommodate time-varying covariates and the fact that different members of the cohort participated in each of the four cohort surveys.



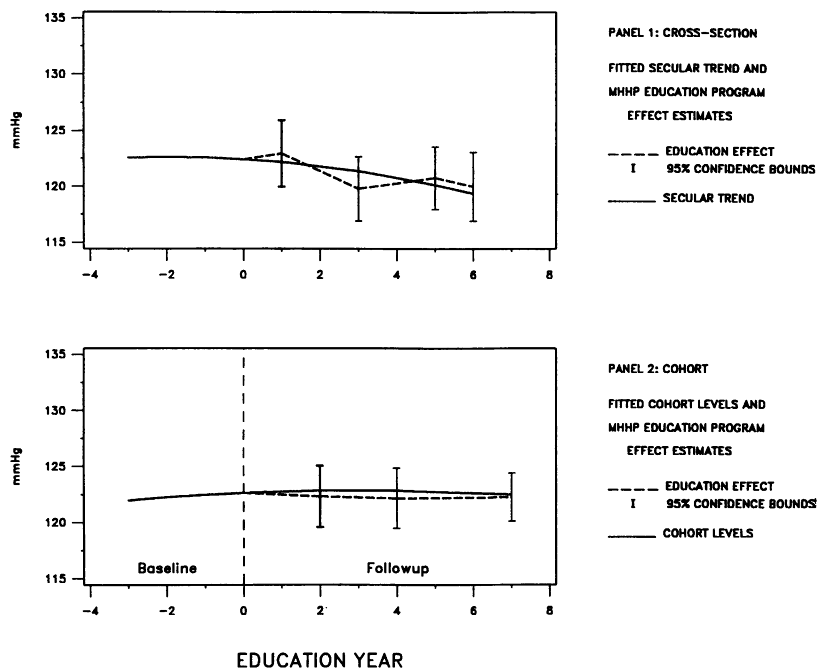
Note. Adjusted for age, education, and marital status. MHHP = Minnesota Heart Health Program.

FIGURE 4—Cigarette smoking in males: results of the MHHP education intervention program.



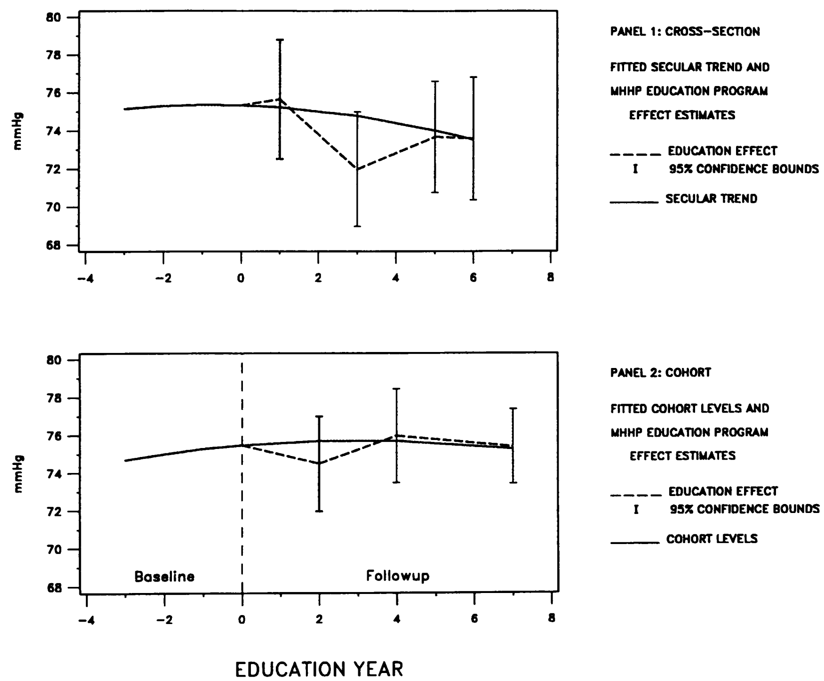
Note. Adjusted for age, education, and marital status. MHHP = Minnesota Heart Health Program.

FIGURE 5—Cigarette smoking in females: results of the MHHP education intervention program.



Note. Adjusted for age, gender, education, seasonal trend, cuff size, observer, and location of blood pressure measurement. MHHP = Minnesota Heart Health Program.

FIGURE 6—Systolic blood pressure: results of the MHHP education intervention program.



Note. Adjusted for age, gender, education, seasonal trend, cuff size, observer, and location of blood pressure measurement. MHHP = Minnesota Heart Health Program.

FIGURE 7—Diastolic blood pressure: results of the MHHP education intervention program.

Results

Survey Participation

A total of 20 184 eligible adults age 25–74 years completed the home interview, and 18 062 completed the survey center protocol. Participation rates were stable across all years and communities: enumeration averaged 96.1% of the selected households, home interviews averaged 87.9% of the selected adults, and the total survey response averaged 78.7%.

Of the participants from the baseline cross-sectional surveys, 7097 were randomly selected for the cohort surveys; the refusal rate was 14.9% and the population was relatively stable, with 67.1% of the original group living in the town and participating at the end of the study. The remainder moved or died. Those lost to follow-up were compared with those retained. The ones lost to follow-up had higher smoking rates and lower levels of blood cholesterol, but there was no evidence of differential attrition between the education and comparison sites. The only differences between the education and the comparison communities on loss to follow-up were in body mass index at the 7-year follow-up survey; those lost from the education communities were slightly leaner than those lost from the comparison communities (body mass index of 25.4 vs 25.9).

Exposure to Risk Reduction Activities

Figure 2 summarizes exposure to risk reduction activities, and Table 1 presents the year-specific means for the exposure summary score; only cross-sectional data are presented because the exposure measures were not included in all cohort surveys. The solid line represents the secular trend estimated for exposure based on all nonintervention stratum-specific city-year means and indicates that exposure to these risk reduction activities increased over time in the comparison communities. The dashed line illustrates the Minnesota Heart Health Program effects at 1, 3, 5, and 6 years of intervention. Exposure was significantly higher in the education communities compared with the comparison communities after 1 and 3 years, but not after 5 or 6 years.

Blood Cholesterol Level

Figure 3 and Tables 1 and 2 summarize the findings for blood cholesterol. In the cross-sectional data, the secular trend showed a steady decline in the comparison communities (about −1.12 mg/dL per year). The mean blood cholesterol was lower in the education communities during the first 3 years of the intervention program and higher in the final 2 years. None of these differences were statistically significant. The cohort findings were similar.

Smoking Prevalence

Figures 4 and 5 and Tables 1 and 2 summarize the findings for cigarette smoking. The response to the intervention program differed by gender, so the figures and tables are gender specific. Among men, there was a downward trend in the comparison communities, both in the cross-section and in the cohort (about −1.5% per year), and there was no added intervention effect. Among women, the secular trend was small in the cross-section, and there was a statistically significant treatment effect (about −1.4% per year) that remained after we corrected the smoking self-report data for underreporting by using serum thiocyanate levels (data not shown). In the cohort, there was a marked decline in smoking prevalence among women and only limited evidence of an intervention effect.

Blood Pressure

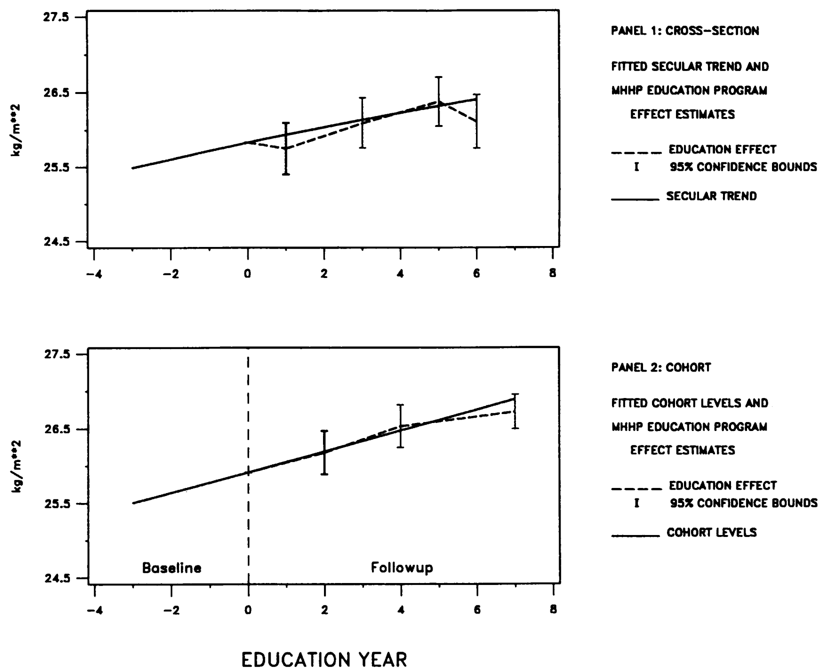
Figures 6 and 7 and Tables 1 and 2 summarize the findings for blood pressure. In the comparison communities, there was evidence of a declining secular trend in the cross-section (averaging −0.4 mm Hg for systolic blood pressure and −0.2 mm Hg for diastolic blood pressure per year) and a flat or slightly rising trend in the cohort, as would be expected with aging. In the education communities, both measures had an additional modest decline after 3 years of intervention in the cross-section and after 2 or 4 years in the cohort; however, none of these changes were statistically significant.

Body Mass Index

Figure 8 and Tables 1 and 2 summarize the findings for body mass index. Both the secular and cohort trends were positive (about +0.1 kg/m^2 per year), and there was no evidence of an intervention effect.

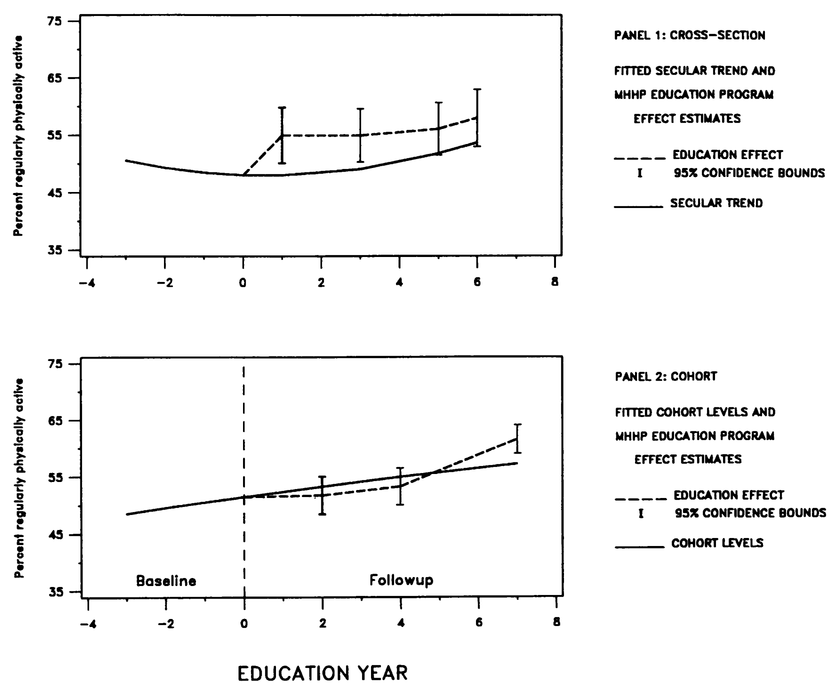
Regular Physical Activity

Figure 9 and Tables 1 and 2 summarize the findings for regular physical activity. The secular trend declined initially but then rose over the last 4 years of the study. The Minnesota Heart Health



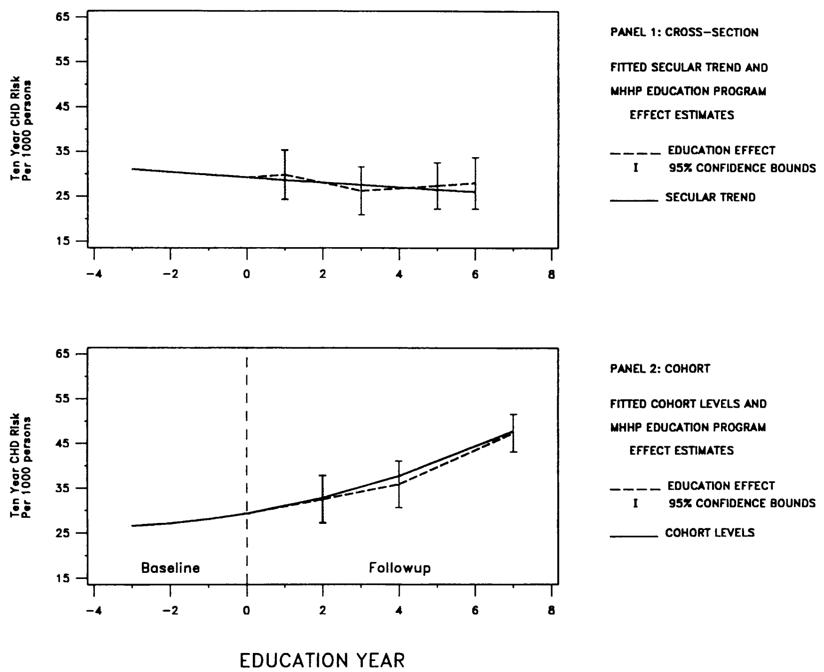
Note. Adjusted for age, gender, education, marital status, and seasonal trend. MHHP = Minnesota Heart Health Program.

FIGURE 8—Body mass index: results of the MHHP education intervention program.



Note. Adjusted for age, gender, and education. MHHP = Minnesota Heart Health Program.

FIGURE 9—Regular physical activity: results of the MHHP education intervention program.



Note. Risk scores were computed by applying the coefficients of Leaverton et al.[20] to the predicted risk factor levels for each participant obtained from the individual risk factor analyses. CHD = coronary heart disease; MHHP = Minnesota Heart Health Program.

FIGURE 10—Coronary heart disease risk score: results of the MHHP education intervention program.

intervention program accelerated this secular trend significantly, especially during the first 3 years of the intervention program. The cohort data suggest a steady increase in self-reported regular physical activity in all communities over the course of follow-up; the education communities exceeded the comparison communities only at the last follow-up survey. We also analyzed the more extensive physical activity data based on the Minnesota Leisure Time Physical Activity Questionnaire, which was answered by a random half of the Minnesota Heart Health Program survey participants. Unlike the findings based on the single question concerning regular participation in leisure time physical activity, results of the longer questionnaire showed a small increase in kilocalories per day expended in leisure time physical activity in the early years of the education program, but a small decrease in later years (data not shown). Time spent in heavier-intensity activities appeared to decrease slightly in the education communities by the end of the program. Resting pulse rate trends (data not shown) reflected the self-reported changes, with lower pulse rates in the education communities associated with higher reported physical activity levels.

Coronary Heart Disease Risk

Figure 10 and Tables 1 and 2 summarize the risk score findings. Risk of death from coronary heart disease declined over time in the cross-section in both the education and the comparison communities, but there was little evidence of an intervention effect. The cohort data reflected increasing risk as the cohort aged, but again, there was little evidence of an intervention effect.

Discussion

The differences observed here between the education and the comparison communities with respect to population-wide risk factor changes were less than postulated. There are several potential explanations for these findings. First, it is apparent that there were strong and favorable secular trends of both increasing health promotion activities and declining risk factors for coronary heart disease in all study communities. Second, it is apparent that the net improvements in health promotion activities and individual risk factors that can be attributed to the Minnesota Heart Health Program intervention were modest, generally of limited duration, and usually within chance levels. In light of the results from previous studies that have supported the efficacy of many of the Minnesota Heart Health Program intervention components in targeted populations, we cannot conclude that those components are ineffective. Instead, we conclude that the Minnesota Heart Health Program intervention was unable to generate enough additional exposure to those risk reduction activities in a large enough proportion of the population to exceed the remarkably favorable secular trends that were ongoing in the study communities. In the next several paragraphs, we review the evidence that led us to this conclusion, consider how these findings compare with the results from similar studies, and consider the implications for public health practice and policy.

Consider first the data on the secular trends for exposure to health promotion activities related to coronary heart disease (Figure 2). Those results suggest that exposure grew steadily in both the comparison and education communities. Examination of the individual items in the exposure score revealed that the net increase in the education communities was attributable largely to higher rates of exposure to cholesterol screening, health projects or surveys, and restaurant menu labeling programs. Other exposure measures showed little difference between the education and the comparison communities. These results suggest that in spite of the Minnesota Heart Health Program's intense intervention program, the increase in such activity over the growing levels observed in the comparison communities was surprisingly limited. This interpretation must be tempered by the limitations inherent in the exposure measures themselves, which assessed whether or not respondents had been exposed to a particular type of risk reduction message or activity and did not discriminate among exposures on the basis of their quality, intensity, or duration. Even so, the exposure data suggest that the Minnesota Heart Health Program may not have added a great deal to the level of risk reduction activity that would have been expected without the program. It may be that the Minnesota Heart Health Program represented too small a fraction of the total exposure to messages related to coronary heart disease to make much difference, or that the Minnesota Heart Health Program supplanted activities that might otherwise have developed on their own. Either way, the net gain in exposure was modest.

Consistent with the favorable secular trend in exposure to risk reduction messages and activities, the cross-sectional results indicate that there were beneficial and often strong trends for each risk factor, with only two exceptions (smoking in women and body mass index). For example, smoking prevalence declined in men by 11.3%, systolic blood pressure declined by 6.3 mm Hg, and total blood cholesterol declined by 11 mg/dL. The major surprise with regard to these secular trends was their magnitude, because only small changes had been expected in these risk factors when the study was designed in 1978. Instead, the improvements in the secular trends were often much greater than the intervention effects hypothesized for the Minnesota Heart Health Program (e.g., hypothesized effects were for a 3% decline in smoking prevalence, a 7 mg/dL decline in total blood cholesterol, and a 2 mm Hg decline in systolic blood pressure). We note as well that the secular trends were greater than those previously observed nationally in the National Health and Nutrition Examination Survey[52] or regionally in the Minnesota Heart Survey.[53]

The cross-sectional results suggest intervention effects in self-reported smoking prevalence among women and in self-reported physical activity in both men and women; however, the cohort data did not support intervention effects in any of the risk factors. In spite of an extensive effort to explain the difference in smoking outcomes for women between the cross-section and the cohort, no explanation has been found. Because smoking in women was the only risk factor that showed a flat trend over time in the comparison communities, this finding may indicate that the Minnesota Heart Health Program intervention was able to induce a favorable slope in the absence of a favorable secular trend. The increased effect observed toward the end of the study is also consistent with the increased delivery of antismoking messages and activities late in the intervention program. The follow-up analyses for physical activity also suggested that the apparent increase in the proportion of the population who engaged in physical activity in their leisure time was the result of an increase in the proportion who engaged in light activity, not an increase in the proportion who engaged in moderate or vigorous activity. This may explain the absence of a Minnesota Heart Health Program effect on body mass index in spite of the apparent effect on physical activity. Taken together, the risk factor results are consistent with the exposure data and suggest modest variation in coronary heart disease risk factors around their secular trends; the data provide little evidence of any broad or significant acceleration of those secular trends that can be attributed with confidence to the intervention program.

Because data on morbidity and mortality are not yet available, we must look to the coronary heart disease risk score for preliminary evidence of the net effect of the intervention program on the population risk for coronary heart disease (Figure 10). The secular trend in the cross-sectional data is consistent with the trends seen in the exposure and individual risk factor data: the estimated 10-year risk improved by 5.0 predicted deaths per 1000 persons from coronary heart disease over the 9 years of the study. The intervention effect is also consistent with the previous results. As with the risk factors, the improvement in estimated risk due to the secular trend was also larger than the improvement that had been hypothesized for the Minnesota Heart Health Program.

Taken together, the results presented in this paper paint a picture of modest and time-limited improvements in exposure to coronary heart disease risk-reducing messages and activities and in coronary heart disease risk factors, usually within chance levels, with no evidence of any cumulative effect on the estimated risk of dying from coronary heart disease. There are several competing explanations, however, and these should be considered.

One competing explanation is that the intervention components themselves did not work. However, there is extensive published research from this study and others demonstrating the efficacy of many of those risk reduction strategies, so this alternative is simply not plausible.[25-47] A second explanation is that the intervention program may have focused on the wrong population segments or used the wrong mix of intervention components. The exposure data suggest that the Minnesota Heart Health Program succeeded in distributing its programs and activities evenly across the strata defined by age, gender, and educational attainment, consistent with the population-based approach of the study, and we cannot know whether the program might have been more effective had it been focused on a particular population segment. In terms of program components, the Minnesota Heart Health Program relied on mass media channels to achieve its awareness goals and on face-to-face direct education activities and communitywide events to achieve its goals for behavior change.[54] Unlike today, there was little support when the Minnesota Heart Health Program was conceived in 1978 for policy-level interventions such as restrictions on smoking and more accurate labeling of food products. Although politically more difficult, these interventions may prove to be more effective than the traditional health education strategies of the 1980s, and it may be that a community program built around a combination of public policy initiatives and the more traditional health education strategies could be more effective. A third alternative explanation is that the Minnesota Heart Health Program's working definition of the community may have been too narrow. The Minnesota program attempted to change the health behaviors and risk behaviors of the residents of three specific communities, with no effort or ability to control or change the broader social milieu in which those communities existed. Just as we have learned that it is difficult to change the behavior of individuals without changing the communities in which they live, we may be learning that it is difficult to change the behavior of whole communities without changing their broader social environment as well. A fourth and final alternative explanation is that health promotion activities such as those developed and implemented in the education communities spread rapidly in the region and effectively "contaminated" the comparison communities. The exposure data presented in Figure 2 provide support for this alternative.

The results from the Minnesota Heart Health Program can be compared with those reported by the Stanford Three- and Five-Community Studies and the North Karelia Study. They also observed modest and often variable improvements in coronary heart disease risk factors after a period of communitywide intervention. In the North Karelia Study,[11] improvements in the intervention community were substantial, but similar trends occurred in the comparison area. In the Stanford Five-Community Project, where the secular trends were not as strong, the risk factor changes were larger and frequently significant.[9] Findings in the Stanford Three- and Five-Community Projects were less frequently significant in analyses conducted at the city–year level, as we have done in this paper; even so, significant intervention effects remained for some outcomes, including their coronary heart disease risk score.[9,12]

Given the general consistency of the Minnesota Heart Health Program results, it is important to consider the implications of these findings for public health practice and public policy. It is tempting to interpret these results as indicating that the intensive communitywide cardiovascular risk reduction program was ineffective, but that would be an oversimplification. Many of the individual components of the Minnesota Heart Health Program intervention have been shown to be effective in earlier studies. Those components, such as risk factor screening and education, classes for smoking cessation, and dietary change, are still recommended for use by individuals, groups, and communities. What we now recognize is that it is far easier to change the risk profiles of the people who participate in those programs than to engage a large enough fraction of the community to change risk profiles of the entire community. □

Acknowledgments

This research was supported by a grant from the National Heart, Lung and Blood Institute (R01 HL 25523).

The authors wish to thank the staff, students, and volunteers who worked on the Minnesota Heart Health Program. Particular thanks to the citizens and leadership of Mankato, Minn; Fargo, ND; Moorhead, Minn; and Bloomington, Minn. We also wish to recognize F. Gerald Kline, PhD (deceased), and Henry L. Taylor, PhD (deceased), for their many contributions. Finally, we wish to thank the members of the MHHP Scientific Advisory Board for their guidance throughout the study: Thomas Cook, PhD, Northwestern University; Leslie Kish, PhD, University of Michigan; John W. Farquhar, MD, Stanford University; Lawrence W. Green, DrPH, University of British Columbia; Lester Breslow, MD, MPH, University of California at Los Angeles; Kenneth J. Rothman, DrPH, EPI Resources; and Lee Stauffer, PhD, MPH, University of Minnesota.

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